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NAVAL ORDNANCE LABORATORY MEMORANDUM 10,003

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25 January 1949

From: E. H. Eyster
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Subj: Studies of the ERL Type 12 Drop-Weight Impact Machine at NOL. (NOL-37-Re2c-19-1b)

Abstract: This memorandum is, in a sense, a continuation of OSRD Report No. 5744, but is at the same time a record of the non-routine work done with the Impact Machine by the High Explosives Section over a two-year period except for gas-collection experiments, which will be described in a separate memorandum.

After describing the machine and tools employed, the basic test procedures, method of treating data, sample preparation, and loading method are briefly reviewed. The electronic method of evaluation of test results, newly adopted at NOL, is described in detail in an appendix prepared by its designer, S. J. Jacobs. Preliminary studies of this electronic noise indicator, as used with the impact machine, are then reported; these enable a suitable choice of standard noise level cut-off to be made. Using this evaluation technique, a systematic series of 120 fifty-shot "up and down" runs are then reported, which were made with six different explosive samples. These data are then considered and analyzed from a number of points of view. It is shown that in general, separate determinations of 50% points with these techniques are subject to errors not included in the A-M method's estimate of error, but that by making comparisons in "group-tests", the estimated errors in the ratios of 50% points, provided by the A-M method, are adequate to describe the results. Of the six explosives studied, five give normal distributions (cumulative) of percent explosion against the logarithm of the drop-height. Four of the samples give σ-values (on this normalized height scale) which are not significantly different, but of the other two samples, one displays a significantly greater, and the other a significantly smaller σ than the average for the first four samples. The memorandum concludes

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with a number of miscellaneous considerations; e.g., the effect of sample weight on 50% point.

Foreword: This report is intended to collect in one usable source the results of our impact-test research for a two year period. The data and factual statements are believed to be accurate, and the opinions are the well-considered ones of the authors. The Naval Ordnance Laboratory is not committed to endorse either.

Refs:
(a) OSRD Report No. 5744; Physical Testing of Explosives, Part II.
(b) Division 8, NDRC, Interim Reports PT-29, p.24, ff; PT-30, p.15, ff; and PT-32, p.21, ff.
(c) A.M.P. Report No. 101.1R; Statistical Analysis for a New Procedure in Sensitivity Experiments.
(d) Division 8, NDRC, Interim Report PT-25, p.22, ff.
(e) Division 8, NDRC, Interim Report PT-26, p.14, ff.
(f) Statistical Methods for Research Workers, R. A. Fisher, Tenth Edition, Oliver and Boyd. (1946).
(g) NavOrd Report 85-46, p.81, ff.
(h) Effects of Non-normality upon Staircase Methods of Sensitivity Testing, by D. F. Votaw, Jr. Statistical Research Group, Princeton, New Jersey.
(i) NavOrd Report 65-46; "Staircase Methods of Sensitivity Testing".
(j) "The Use of Electrical Cables with Piezoelectric Gages", R. H. Cole, NDRC Report A-306, OSRD 4561.
(k) "Electrical Instruments for Study of Underwater Explosions and other Transient Phenomena"; R.H. Cole, D. Stacey, R.M. Brown, NDRC Report A-360; OSRD 6238.

Encls:
(A) Appendix 1. "The Electronic Noise Indicator for the Impact Machine", by S. J. Jacobs.
(B) Tables I - III.
(C) Plates I and A-I. (NOL Sk B-67695)

I. Introduction

The results of four years' study and development of laboratory Drop Weight Impact Test Machines are contained in the report of reference (a). This report extends the work of that reference, and has been written upon the assumption that reference (a) will be available or familiar to the interested reader. One of the 337-cm. drop machines from the E.R.L. has been acquired by the Explosives Division of the Research Department at the NOL, and, equipped with the ERL Type 12 tools, has been subjected to a performance study during the past two years. Almost from the outset in its use at the NOL this machine has been employed with an electronic "noise-meter", to be described in this memorandum (See also reference (a) p.22, ff.). With such a device presumably eliminating those causes of systematic error associated with the observer's judgment of the result of a single drop-test, homogeneity or stability tests of the sort described for RDX in reference (b) have been carried out on a variety of explosives. Such tests have, however, been broadened in scope by study of extended series of two-member group-tests, so that not only the stability of 50% explosion heights, but also of their ratios, can be inspected. These extended series of 50-shot tests have, moreover, been so connected that they supply, at the same time, 1000-shot tests of six explosives. With such large numbers it becomes possible to consider with more meaning the distribution functions generated in these tests, and to make distinctions among the population standard-deviations. These possibilities now also permit a more rational discussion of the choice of "percent-points" to be determined in general sensitivity testing. During the period of study covered by this memorandum, there have, of course, been carried out a large number of purely routine sensitivity comparisons of various explosive samples; these have been, in general, of purely local or special interest, and will not be considered here.

II. Apparatus and Procedure

A. Impact Machine

The NOL machine, received from ERL, is briefly described in reference (a) and is drawn in detail in the following NOL Sketches:

NOL/SK A-63875 to A-63922

NOL/SK B-98874 to B-98903

NOL/SK C-96249 to C-96261

NOL/SK D-97375 to D-97379

Assembly-NOL/SK D-97378

The above drawings show the machine equipped with a gas-collection chamber, which has not been used in the studies reported in this memorandum. The tools used are shown in NOL/SK's 80774, 80775, 85469, 85470, 87434, 88956, 89003, 89004, 92767, 96942, and 97025, while details of the concrete bedding are shown in NOL/SK-96926. Although these drawings specify a drop-weight of either 2.5 or 5 kg., the former has been used exclusively in the work reported here.

B. Basic Test Procedure and Data Reduction

The basic unit test employed in this work has been made by the 50-trial A.M.P. "Up and Down" method using test heights equally spaced in the logarithm of the height, on a 0.1 log unit interval. The results have been analyzed by the method of reference (c). The application of this experimental procedure and method of analysis to the ERL Type 12 machine has been described in considerable detail in reference (d). Such discussions need not be reproduced here. The nomenclature and significance of symbols employed in this memorandum will be uniform with these of references (a) through (d), and are briefly as follows:

- m - the 50% explosion height on the normalized (logarithmic) scale.
- h - the 50% explosion height in centimeters.
- σ - the estimated standard deviation of the parent population.
- σ_m - the estimated standard error of m.
- σ_σ - the estimated standard error of σ

C. Sample Preparation

Those materials which are normally cast loaded are prepared for test by casting out in a thin sheet, gently grinding in a mortar, and screening. The test sample is a mixture of equal weights of the 16-30 and 30-50 U. S. Standard Sieve cuts. Other materials which cannot be cast, such as RDX, PETN, Explosive D, etc., are normally tested as received.

D. Loading

In routine testing, samples are loaded into the machine for test on a volumetric basis, using small scoops. For sensitivity comparisons, test weighings are first made and scoop-sizes chosen so that samples of each explosive weighing 35 ± 2 mg. are delivered. For most of the purposes of the studies reported here the average scoop weight is of no special importance (except see Section III E).

E. Evaluation of Individual Trials

For all sensitivity tests reported here, the decision that the result of a given trial was an "explosion" or an "inert" has been made by the electronic noise indicator, or "noisemeter", which is described in detail in enclosure (A) of this memorandum.

stability of results made with the Type 12 machine were rather qualitative ones (reference (e)). With an explosive so sensitive that there was no interpretation problem (e.g. PETN, as shown in Figure 1) some work was done with the ERL Type 3 machine (reference (b), which showed that even in the absence of interpretational difficulties, a series of 50% heights did not, in general, show as small a variance as would be expected from the σ_m-values calculated. With the grosser aspects, at any rate, of the interpreation problem solved by the electronic noise indicator, it has seemed proper to extend studies like those of reference (b) to the Type 12 machine.

2. Plan of the Experiment

Three pairs of explosives were selected for tests. A series of twenty group-tests was made with each pair, each group-test consisting of the alternate firing of the two explosives until a total of 50 shots had been made on each sample. One additional condition was observed for each pair - each test after the first was a continuation of the previous test. In this way the twenty 50-shot tests of each explosive also constituted one 1000-shot test. The pairs chosen were RDX-PETN, Composition B - Composition B, D-2, and Composition A-3-HBX. The RDX, PETN, and Composition A-3 were tested as received, while the other samples were cast and screened to standard grist (See Section II C). Roughly two group-tests were made each day.

3. Experimental Results

The detailed results, calculated by the procedure of reference (c), are presented in Table II; pairs comprising a group-test bear the same test numbers, and the final row contains the analysis of the complete data, treated as one 1000-shot run. In a few cases the Table states "Too small to calculate"; this means that the estimates were found to be too small to calculate by the procedures of reference (c). We shall now consider the meaning of these results.

4. Homogeneity of m-Values

The six series of m-values were first tested for homogeneity by the procedure of reference (c), p. 26, ignoring the fact that they were really generated as three series of paired values. The results, in the nomenclature of reference (c), are:

	Qr (calc)	L	Qr (5% level)	Qr (1% level)
PETN	31.52	19	32.79	40.39
RDX	54.69	19	32.79	40.39
Comp. A-3	82.63	17	30.02	37.29
Comp. B	69.07	18	31.41	38.85
HBX	54.21	18	31.41	38.85
Comp. B, D-2	83.27	18	31.41	38.85

The above numbers show that only the PETN series is homogeneous at the 5% and 1% significance levels, all other series being inhomogeneous at both significance levels. In the light of the insensitivity of the PETN m-values to changes in noisemeter gain, as shown in Figure I, one might be tempted to attribute these results to uncontrolled gain fluctuations in the noisemeter; actually, however, this does not seem to be a justifiable conclusion. If it were correct, one would expect a regular deterioration in homogeneity with decreasing sensitivity, which is not found. Moreover the inhomogeneities reported for RDX in the first two reports of reference (b) were obtained under circumstances where the constancy of result evaluation could not be suspected. We believe, therefore, that although such homogeneous series may occasionally occur, one must anticipate that with this machine, in its present condition and mode of operation, the generation of inhomogeneous series will be the rule - i.e., there are uncontrolled sources of error which elude estimation in the determination of σ_m in one 50-shot run.

5. Homogeneity of Differences in m-Values

Next, the analysis actually proper under the experimental circumstances was made; i.e., the stability of the differences of the m-values obtained in the two member group tests was studied. Results analagous to those of the previous section are:

	Q_r (calc)	L	Q_r (5% level)
RDX - PETN	19.59	19	32.79
B, [illegible]	24.74	17	30.02
HBX-A-[illegible]	19.07	16	28.61

The above numbers show that each of these three series of differences is homogeneous at the 5% level. By combining these three Q_r's (as one combines X^2 values - see reference (f), p.81) it may further be shown that not only are these series homogeneous individually at the 5% level, but also that they are homogeneous at the same level as a group. It should be remarked that these pairs of explosives were chosen to be at least roughly comparable in sensitivity, but are otherwise quite various. RDX and PETN are both pure crystalline compounds, Composition B and Composition B, D-2 differ only in the added desensitizing wax present in the latter, while Composition A-3 is a waxed RDX, and HBX is an aluminum-bearing explosive mixture. We may therefore conclude that when pairs of explosives (and presumably larger groups) are tested together (for larger groups a truly randomized arrangement would be preferable), the estimates of error, provided by the methods of reference (c), are appropriate for use in significance tests within the group. That this is true in general, particularly where a group contains members of widely varying sensitivities, has not been shown, but in actual fact one is really interested only in significance tests and estimates of error when comparing explosives of nearly equal sensitivity, so for all practical purposes the demonstration is general.

C. Normality Studies

The logarithmic normalized height scale was first adopted at ERL after a series of experiments suggested not only that it appeared to give more nearly normal distributions of the probability of explosion than the heights themselves, but particularly when it appeared that the σ's which were obtained using the logarithmic scale were essentially equal for all explosives (see reference d). A much more extensive series of experiments made later (reference g) under circumstances which permitted testing the data for normality on both the logarithmic and unmodified height scale assumptions showed that neither one was best for all samples tested. The six series which have been determined in these studies may be analyzed as 1000 shot runs, and tested for normality by the procedure of reference (c), p. 29, ff. (as corrected in the errata sheet). The pertinent results, in the notation of reference (c), are:

	L	χ^2	χ^2 (5% level)	χ^2 (1% level)
PETN	2	1.985	5.991	9.210
RDX	2	1.505	5.991	9.210
Comp. A-3	2	3.520	5.991	9.210
Comp. B	2	10.250	5.991	9.210
HBX	3	5.570	7.815	11.345
Comp. B, D-2	3	3.527	7.815	11.345

These data show that all of the explosives except Composition B give distributions normal in the logarithm of the height at the 5% level, but that Composition B deviates from normality even at the 1% level; this deviation must be admitted as significant, but does not seem to be correlated with an especially high Q_r in the tabulation of Section III B 4. Viewed as a whole, however, these data do seem to conform reasonably to normality in the logarithm of the height, and the use of this scale remains of great practical value. Attention is directed in this connection to the recent report of reference (h), which discussed the effect of departure from normality upon the estimates of population parameters provided by these "Staircase" experiments.

D. Population Standard Deviations

In references (b) and (d), series of many σ values determined for various explosives were studied. These were obtained in 50-trial tests, and were, accordingly, not known with great accuracy. Determined with the aid of the logarithmic height scales, they appeared in general to constitute a homogeneous set of statistics (in the sense of the homogeneity test of reference (c), p. 26). The precision with which the 1000 shot runs, performed here, determine σ is great enough so it is of interest again to consider this matter.

The following pertinent data are reproduced from Table II:

Explosive	σ	σ_σ
RDX	0.1123	0.00717
PETN	0.1343	0.00910
Comp. B	0.1306	0.00874
Comp. B, D-2	0.1324	0.00891
HBX	0.1894	0.01450
Comp. A-3	0.0870	0.00519

Comparisons certainly must be valid among the pairs of σ-values determined in one two-member group test. When so made, the σ-values for RDX and PETN and for Composition B and Composition B, D-2 are not distinguished as different at the 5% level, while the σ-values for HBX and Composition A-3 are readily distinguished as different at the same level. Comparisons among all six values are perhaps less valid, but may well be meaningful for such long runs. The whole set of six is, of course, not a homogeneous set in the sense of reference (c), p. 26, but the first four σ-values are; the Composition A-3 value is significantly smaller than their average, while the HBX value is significantly greater. The practical meaning of these results is that whereas the first four explosives may be said to have displayed sensitivities in this test which may be characterized simply by stating their m-values or 50% explosion heights, the latter pair do not; their relative sensitivities depend up the severity of the blow to which they are subjected (or to the "percent-points" at which they are being compared, to choose the alternative basis of comparison). This situation is not really unexpected nor even discouraging; indeed were all σ-values the same, one would begin to doubt that they were actually related at all to the characteristics of the explosive, being simply a measure of the lack of reproducibility in the blow of the machine. It is not clear from these results, moreover, that the sensitivity ordering at any one "percent-point" is more nearly related to "service sensitivity" than that obtained at any other, but the meaning of the whole sensitivity curves, especially as larger and more realistic devices for simulating accidental initiation by impact are developed, may become clearer in the future, and may well aid in understanding the many puzzles of sensitivity.

Using Composition A-3 and HBX, determinations of "percent-points" other than 50% points have been made by us, using the methods outlined in reference (i). Generally speaking, these methods were all satisfactory, and were in adequate agreement among themselves. We are not, however, impelled to choose any of the new ones in preference to the AMP "Up and Down" methods.

E. Miscellaneous Studies

1. Causes of Inhomogeneity of m-Values

Real physical variations in the mechanics of this impact-test must cause the inhomogeneities found in Section III B 4 of this memorandum. We have kept records of the temperatures and of the humidities in the test room, but have not been able to find any significant correlation between them and the m-values. Another possible source of some of these variations does seem to have been detected; this is excessive wear of the plungers. Because of the relatively great stability of the Type 12 tools, where no close dimensional tolerances need be held, we had fallen into careless habits, using plungers until they developed pronounced rings on their flat faces. In the Composition B, Composition B, D-2 series (Table II), for example, plungers were changed in the middle of tests 3-59 and 3-68, and after tests 3-63 and 3-71; each such change was followed by a pronounced drop in the 50% point. Three 50-shot tests were then made with Composition B, D-2, as follows: In test 4-1A a resurfaced, highly polished plunger was used; in test 4-1B a similar plunger slightly "roughed up" with emery cloth was used; and in test 4-1C a used plunger, having a well developed ring and a rough surface, was used. The results follow:

Test	m	h(cm)	σ	σ_m	σ_σ
4-1A	1.9967	99.2	0.0709	0.0154	0.0185
4-1B	1.9950	98.8	0.1858	0.0351	0.0631
4-1C	2.0508	112	0.1220	0.0244	0.0365

There are no distinctions made by these results, but it is interesting to note that the highest result was obtained with the worn plunger.

Accordingly, in the next series, (HBX-Composition A-3), plungers were changed regularly; these changes are indicated in Table II. Unhappily, if the starred and unstarred data are tested separately for homogeneity, they are found still to be inhomogeneous. Thus, although regular replacement of plungers does appear to be helpful, no complete explanation has been found for the variations discovered.

2. Dependence of 50% Point on Sample Weight

Reference (a) presents information concerning the dependence of 50% points on sample weight for the Type 3 machine (p.13). Analogous studies have now been made with the Type 12 machine. Five explosives, covering the sensitivity range of the machine, viz, PETN, Tetryl, Composition A-3, HBX, and TNT were tested in individual 50-shot runs. The data are presented in Table III.

For reasons which are unknown, the HBX data are very badly scattered, while the values obtained for Composition A-3 and TNT are unusually low. All except the HBX data seem suitable for a determination of slope however. An equation of the form

Best Available Copy = ax + b

was assumed where $y = m$ and $x = \log_{10}$ sample weight. a and b were determined by a modified least squares procedure in which the quantity minimized was

$$\frac{(y_i - ax_i - b)^2}{\sigma_{y_i}^2}$$

That is, the data were weighted inversely as the squares of their attendant standard errors. This procedure gives:

$m = 0.6185\ X + 0.1547$ (PETN)

$m = 0.5582\ X + 0.5213$ (TETRYL)

$m = 0.5938\ X + 0.7740$ (Composition A-3)

$m = 0.4827\ X + 1.1428$ (TNT)

Thus the slopes are not greatly different for these four materials; accordingly sensitivity comparisons do not appear, with this machine, to be greatly influenced by choice of sample-weight, provided the same sample weight is used for all materials under comparison.

3. Factors Contributing to σ

Such values of σ as are determined, for example, by treating the data of Table II as 1000-shot runs, contain, in all probability, contributions made by many factors. One such contributor is the same complex of causes which leads to inhomogeneity in these data when analyzed consecutively as 50 shot runs. This contribution could be assessed by appropriate analysis of the data of Table II, but since we do not understand the nature of the complex of causes, it is not especially practical to evaluate their effects in this way, the whole practical content of the results being actually contained in the method (Section III B 4) of avoiding these effects.

Another possible contributor to σ is suggested by the previous section, namely, the variation in sample weights obtained by volumetric loading. Fifty scoops each of TNT and RDX were weighed. The average weights were found to be 31.4 and 30.6 mg., with population standard deviations of 2.1 and 1.6, respectively. On the basis of an average standard deviation of 2.0, of sample weight 32, and the average of the coefficients of X in the equations of the previous section, one would expect a contribution of about 0.015 to σ from such causes. A few 50-shot comparisons have been made between weighed and volumetrically loaded samples, but these runs were too short to reveal any differences.

Another possible contributor to σ is the lack of reproducibility in the physical arrangement of the explosive grains between the tools. A few preliminary experiments on samples prepared as cast wafers have not yet revealed any real decrease in [illegible] obtainable by this method of securing physical uniformity.

IV. Acknowledgement

Mrs. S. Duck, Ordnanceman 3/c, operated the machine during the course of these experiments. Her patience and attention to detail contributed much to the progress of the work.

E. H. Eyster

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APPENDIX 1

The Electronic Noise Indicator for the Impact Machine

The noise indicator or "noisemeter", as this device is usually called, is a device which gives a visual signal to indicate whether a given noise from the impact test is above or below a given reference level. The instrument uses a piezoelectric microphone (Rochelle salt type) essentially as a peak pressure device. The pressure signal incident on the microphone produces a charge on the microphone which, within the frequency limits of the microphone, is proportional to the pressure. This charge produces a voltage which is proportional to the charge across the capacitance of the microphone, a padding capacitor used for calibration, and the associated input circuit capacitance. The voltage is amplified so that an output of about 40 volts is obtained to correspond to the voltage produced by the microphone at the desired reference level. The amplified voltage is used to trigger a small thyratron biased to about 40 volts below the triggering voltage. Triggering the thyratron causes a neon glow lamp to light, thus indicating that the peak sound level actuating the microphone exceeded the reference level selected. A sound level below the reference level fails to trigger the thyratron and so fails to light the neon indicator lamp. The circuit is arranged so that the only variable not under the control of the operator is the response of the microphone. This response may be a function of the ambient temperature.(1) Operational control is achieved by introducing the calibrating signal at the input of the amplifier. The calibrating signal is introduced as a Q calibration(2) (Q = quantity of charge) which then calibrates the instrument for microphone output independent of capacity in the microphone circuit. Triggering at the desired level is accomplished by adjusting the amplifier

(1) Recently two types of crystal mixes having low temperature coefficients have been commercially introduced. One uses ammonium dihydrogen phosphate, the other a ceramic of barium titanate. Either type in this application might need an additional amplification stage.

(2) For more details of the Q calibration, see references (j) and (k).

In this diagram:

C_m = microphone capacitance

C_1 = Line and stray circuit capacitance

C_c = calibration capacitance ($\cong C_m + C_1$)

R_c = resistor across which calibration voltage E_c is developed

R_g = grid resistor

E_g = voltage input to amplifier

E_c = calibration voltage

Q = charge developed by microphone for a given acting pressure, p.

The microphone may be considered as a charge generator in parallel with a capacitance, C_m. When a pressure acts on the microphone the charge developed is:

$$Q = K A p$$

If $p = p(\text{time})$ then $Q(t)$ is a linear function of $p(t)$ within the limits of the linear response range of the microphone. K is the piezoelectric constant and A is the gage area. K is a function of temperature but in this application the temperature coefficient seems small enough to be neglected for the ambient range normally encountered*.

The voltage, E_g, developed by the sound pressure p is:

$$E_{g,m} = \frac{K A p}{C_m + C_1 + C_c}$$

(In this equation E_c is zero and the effect of R_c and R_g may be neglected because R_c is very small and R_g is very large.)

For calibration; a voltage, E_c, is applied as a square

* In this connection it might be stated that Rochelle salt is far from an ideal material for the microphone because it has a Curie point at 24°C. If more precision were desired it would be well to investigate other P.E. materials such as ADP or tourmaline.

step by switching a constant current through R_c. Then:

$$E_{gc} = E_c \frac{\frac{1}{C_m + C_1}}{\frac{1}{C_c} + \frac{1}{C_m + C_1}}$$

or

$$E_{gc} = E_c \frac{C_c}{C_m + C_1 + C_c}$$

In operation a standard capacitance C_c is plugged into the calibrator, E_c is selected and the gain is set so the instrument just triggers when E_c is switched in. This then establishes a minimum level for triggering by the microphone given by:

$$E_{gm} = E_{gc}$$

Then:

$$P_{trigger} = \frac{E_c C_c}{K A}$$

In this equation all circuit variables have been eliminated except the calibrating voltage and capacity. It is thus possible to reproduce trigger settings independent of variation of microphone cable length or variation of microphone capacitance.*

* There is some evidence that the change of capacitance of a Rochelle salt crystal somewhat parallels its change of piezoelectric constant. This would make a Q calibration less satisfactory than a voltage calibration for this type of microphone. Actual tests with the impact machine over a rather wide range of ambient temperature have indicated satisfactory agreement of 50% points however. An idea of the probable magnitude of the temperature effect on the Rochelle salt microphone may be gained from some data in NOLM 5125 on a Brush Hydrophone. This showed the following response (approximate), at 30 and 150 cycles as a function of T.

T, °F	Response, microvolts/bar (dyne/cm²)
50	100
70	130
74	155 (max)
90	125
100	120

Notes on Operation:

1. It should be noted that the calibrated level for triggering is proportional to E_cC_c and not just E_c. However after selecting a given value of C_c, E_c then naturally is a measure of the trigger level.

2. The meter marked M.V. on the schematic is fundamentally an 0-1 milliampere meter. It is used with a 3 position switch, Sw2. In switch position 1 it shows E_c across a 10 ohm resistor and therefore gives a range of E_c from 0 to 10 millivolts. In switch position 2, E_c is across a 100 ohm resistor and the meter then reads a range of E_c from 0 to 100 millivolts. In switch position 3 the meter is a 0 to 100 voltmeter used to measure the voltage on the cathode of V4 for adjusting the thyratron bias.

E. J. Jacobs

TABLE I

Dependence of 50% Point On Noise Indicator Gain

Explosive	Gain (E) 20 mv. m (h)	40 mv. m (h)	60 mv. m (h)	80 mv. m (h)
PETN	1.147(14.0)	1.119(13.1)	1.079(12.0)	1.105(12.7)
Tetryl	1.425(26.6)	1.367(23.3)	1.605(40.3)	1.607(40.5)
Comp. B	1.691(49.1)	1.703(50.5)	1.815(65.3)	1.830(67.6)
HMX	1.855(71.6)	1.911(81.5)	2.023(106)	2.084(121)
TNT	1.965(92.3)	2.068(117)	2.255(180)	2.319(208)

TABLE II: Results of Stability Tests

RDX

Tests	m	h(cm)	σ	σ_m	σ_σ
3-16	1.4469	28.0	0.1476	0.0284	0.0459
3-17	1.3683	23.4	0.1525	0.0299	0.0490
3-18	1.4042	25.4	0.0617	0.0137	0.0158
3-19	1.3506	22.4	0.0993	0.0200	0.0274
3-20	1.4028	25.3	0.0993	0.0200	0.0274
3-21	1.3707	23.5	0.1228	0.0241	0.0361
3-22	1.3506	22.4	0.0862	0.0177	0.0229
3-24	1.3931	24.7	0.0678	0.0145	0.0173
3-39	1.4373	27.4	0.0682	0.0146	0.0173
3-40	1.3747	23.7	0.0842	0.0173	0.0222
3-41	1.3988	25.0	0.1155	0.0228	0.0333
3-42	1.3306	21.4	0.0505	0.0116	0.0116
3-43	1.3586	22.8	0.1051	0.0210	0.0294
3-44	1.3787	23.9	0.0842	0.0173	0.0222
3-45	1.3627	23.0	0.0810	0.0168	0.0213
3-46	1.3627	23.0	0.0941	0.0190	0.0256
3-47	1.3787	23.9	0.1233	0.0239	0.0360
3-48	1.3667	23.3	0.1217	0.0239	0.0356
3-49	1.3667	23.3	0.0957	0.0193	0.0261
3-50	1.3506	22.4	0.1254	0.0245	0.0370
1000) shot) run)	1.3777	23.9	0.1123	0.00497	0.00717

TABLE II (Cont.)

PETN

Test	m	h(cm)	σ	σ_m	σ_c
3-16	1.0841	12.1	0.1119	0.0226	0.0325
3-17	1.1008	12.6	0.1502	0.0295	0.0481
3-18	1.1379	13.7	0.1905	0.0360	0.0652
3-19	1.1133	13.0	0.1712	0.0332	0.0574
3-20	1.1532	14.2	0.0617	0.0138	0.0159
3-21	1.0961	12.5	0.0657	0.0141	0.0167
3-22	1.1018	12.6	0.1124	0.0223	0.0321
3-24	1.1201	13.2	0.0814	0.0169	0.0214
3-39	1.1091	12.9	0.1625	0.0316	0.0534
3-40	1.1091	12.9	0.1221	0.0244	0.0364
3-41	1.0657	11.6	0.1087	0.0216	0.0308
3-42	1.0632	11.6	0.1376	0.0272	0.0427
3-43	1.0496	11.2	0.1513	0.0290	0.0475
3-44	1.0632	11.6	0.1376	0.0272	0.0427
3-45	1.0857	12.2	0.1347	0.0262	0.0407
3-46	1.0897	12.3	0.1072	0.0213	0.0302
3-47	1.0817	12.1	0.0967	0.0195	0.0265
3-48	1.0715	11.8	0.1533	0.0300	0.0494
3-49	1.0757	11.9	0.1401	0.0276	0.0437
3-50	1.1178	13.1	0.0920	0.0187	0.0248
1000 shot run	1.0938	12.4	0.1343	0.00583	0.00910

TABLE II (Cont.)

Composition B

Test	m	h(cm)	σ	σ_m	σ_{σ}
3-54	1.8150	65.3	0.0824	0.0170	0.0216
3-55	1.8430	69.7	0.0733	0.0154	0.0189
3-56	1.7950	62.4	0.1084	0.0214	0.0307
3-57	1.8050	63.8	0.0577	0.0131	0.0153
3-58	1.8467	70.3	0.1251	0.0250	0.0377
3-59	1.8190	65.9	0.0808	0.0167	0.0212
3-60	1.7270	53.3	0.1022	0.0205	0.0284
3-61	1.7870	61.2	0.1177	0.0231	0.0342
3-62	1.8050	63.8	0.0857	0.0180	0.0232
3-63	1.7925	62.0	0.0966	0.0199	0.0270
3-64	1.7430	55.3	0.0864	0.0177	0.0231
3-65	1.7590	57.4	0.1276	0.0249	0.0380
3-66	1.7190	52.4	0.1068	0.0213	0.0301
3-67	1.7510	56.4	0.0885	0.0181	0.0238
3-68	1.8070	64.1	0.1100	0.0218	0.0312
3-69	1.7950	62.4	0.1084	0.0215	0.0308
3-70	1.7590	57.4	0.1663	0.0317	0.0540
3-71	1.7950	62.4	0.1084	0.0215	0.0307
3-72	1.6950	49.5	0.1472	0.0283	0.0459
3-73	1.7670	58.5	0.1126	0.0223	0.0322
1000) shot) run)	1.7812	60.4	0.1306	0.00568	0.00874

TABLE II (Cont.)

Composition B, D-2

Test	m	h(cm)	σ	σ_m	σ_σ
3-54	2.0467	111	too small to calculate		
3-55	2.0430	110	0.0602	0.0132	0.0153
3-56	2.0390	109	0.0780	0.0163	0.0204
3-57	2.0950	124	0.0692	0.0148	0.0177
3-58	2.1190	132	0.1068	0.0213	0.0301
3-59	2.0990	126	0.1482	0.0285	0.0464
3-60	2.0133	103	0.0845	0.0177	0.0228
3-61	1.9883	97.3	0.0811	0.0171	0.0217
3-62	2.0510	112	0.1146	0.0226	0.0330
3-63	2.0717	118	0.1486	0.0291	0.0475
3-64	2.0133	103	0.0845	0.0177	0.0228
3-65	2.0070	102	0.1488	0.0286	0.0466
3-66	2.0030	101	0.1745	0.0331	0.0579
3-67	2.0550	114	0.1214	0.0238	0.0354
3-68	2.1190	132	0.0938	0.0190	0.0255
3-69	2.0430	110	0.1513	0.0290	0.0475
3-70	2.0550	114	0.1301	0.0258	0.0397
3-71	2.0508	112	0.1057	0.0215	0.0303
3-72	1.9675	92.8	0.0898	0.0187	0.0247
3-73	2.0133	103	0.1251	0.0250	0.0377
1000 shot run	2.0444	110.8	0.1324	0.0058	0.0089

TABLE II (Cont.)

Composition A-3

Test	m	h(cm)	σ	σ_m	$\sigma_?$
4-2*	1.7430	55.3	0.0479	0.0111	0.0127
4-3	1.7633	58.0	0.0706	0.0153	0.0184
4-4*	1.8593	72.3	0.0816	0.0176	0.0225
4-5	1.8390	69.0	Too small to calculate.		
4-6*	1.7508	56.3	0.0646	0.0142	0.0165
4-7	1.8050	63.8	0.0857	0.0180	0.0232
4-11*	1.7670	58.5	0.0733	0.0155	0.0189
4-12	1.7550	56.9	0.0823	0.0170	0.0218
4-13*	1.7470	55.8	0.0812	0.0168	0.0214
4-14	1.7390	54.8	0.0649	0.0140	0.0164
4-15*	1.7670	58.5	0.0864	0.0177	0.0230
4-16	1.7350	54.3	0.1034	0.0211	0.0295
4-17*	1.7217	52.7	0.0529	0.0122	0.0138
4-18	1.7830	60.7	0.0628	0.0137	0.0159
4-19*	1.7750	59.6	Too small to calculate.		
4-21*	1.8230	66.5	0.0655	0.0141	0.0166
4-23	1.7925	62.0	0.0831	0.0175	0.0224
4-24*	1.7592	57.4	0.0646	0.0142	0.0165
4-25	1.7870	61.2	0.0787	0.0164	0.0205
4-26	1.7830	60.7	0.0490	0.0112	0.0125
1000) shot) run)	1.7696	58.8	0.0870	0.00398	0.00519

* new (resurfaced) plunger.

TABLE II (Cont.)

HBX

Test	m	h(cm)	σ	σ_m	σ_k
4-2*	1.9430	87.7	0.1771	0.0336	0.0590
4-3	2.0430	110	0.0995	0.0200	0.0275
4-4*	2.0750	119	0.1214	0.0238	0.0354
4-5	2.0310	107	0.1250	0.0244	0.0369
4-6*	1.9425	87.6	0.1304	0.0259	0.0398
4-7	2.0800	120	0.1161	0.0234	0.0342
4-11*	1.9870	97.0	0.1048	0.0209	0.0293
4-12	1.9870	97.0	0.1307	0.0254	0.0391
4-13*	1.9008	79.6	Too small to calculate.		
4-14	1.9633	91.9	0.2457	0.0466	0.0953
4-15*	2.0050	101	0.1799	0.0348	0.0615
4-16	1.9425	87.6	0.1304	0.0259	0.0398
4-17*	1.9390	86.9	0.2070	0.0389	0.0734
4-18	1.9710	93.5	0.1560	0.0299	0.0496
4-19*	1.9630	91.8	0.1591	0.0304	0.0510
4-21*	1.9133	81.9	0.3124	0.0587	0.1345
4-23	1.9550	90.2	0.2500	0.0464	0.0958
4-24*	1.9670	92.7	0.0866	0.0177	0.0231
4-25	2.0258	106	0.1595	0.0311	0.0522
4-26	1.9758	94.6	0.1528	0.0299	0.0493
1000) shot) run)	1.9811	95.7	0.1894	0.00800	0.01450

* New (resurfaced) plunger

TABLE III

Dependence of Fifty Percent Point on Sample Weight

Explosive	Sample Weight	m	σ	σ_m	σ_σ
PETN	20 mg.	0.9343	0.1796	0.0347	0.0614
	30	1.0471	0.1719	0.0327	0.0566
	40	1.1791	0.0990	0.0199	0.0273
	60	1.2471	0.0680	0.0145	0.0173
	80	1.3259	0.1326	0.0263	0.0407
Tetryl	20 mg.	1.2551	0.0855	0.0179	0.0233
	30	1.3271	0.1796	0.0340	0.0602
	40	1.3791	0.1766	0.0335	0.0588
	60	1.5259	0.1192	0.0239	0.0354
	80	1.5843	0.0647	0.0143	0.0168
Comp. A-3	20	1.5031	0.0571	0.0127	0.0148
	30	1.6551	0.0822	0.0170	0.0218
	40	1.6926	0.1237	0.0247	0.0372
	60	1.8009	0.0574	0.0130	0.0152
	80	1.8551	0.1127	0.0227	0.0330
HBX	20	1.7926	0.2843	0.0536	0.1174
	30	1.7942	0.4483	0.0850	0.2307
	40	2.0134	0.1251	0.0249	0.0377
	60	2.0676	0.2910	0.0548	0.1213
	80	2.2991	0.0703	0.0150	0.0180
TNT	20	1.8160	0.1559	0.0311	0.0516
	30	1.8231	0.1177	0.0231	0.0342
	40	1.9311	0.1250	0.0244	0.0369
	60	1.9801	0.1430	0.0281	0.0451
	80	2.0634	0.0571	0.0129	0.0142

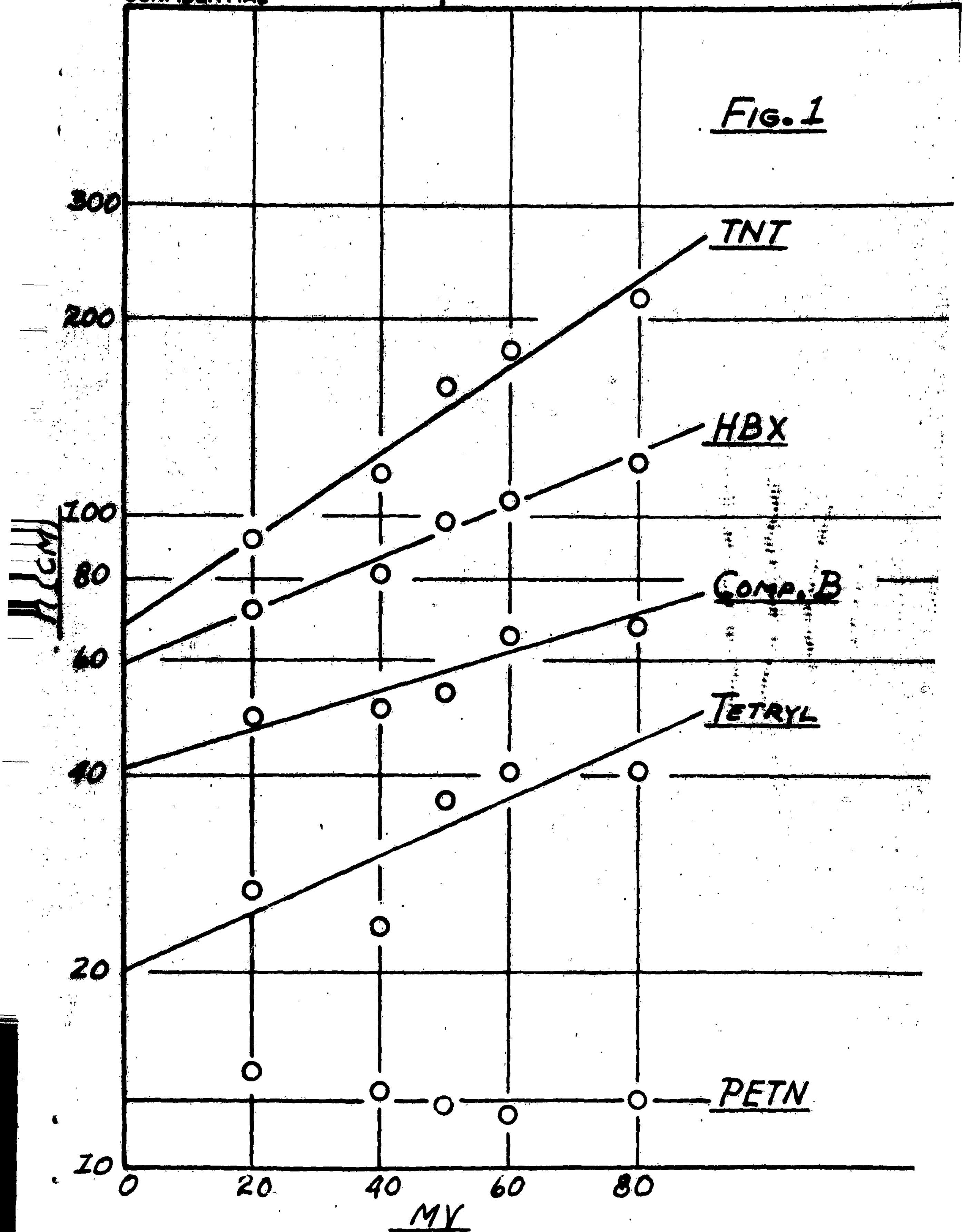
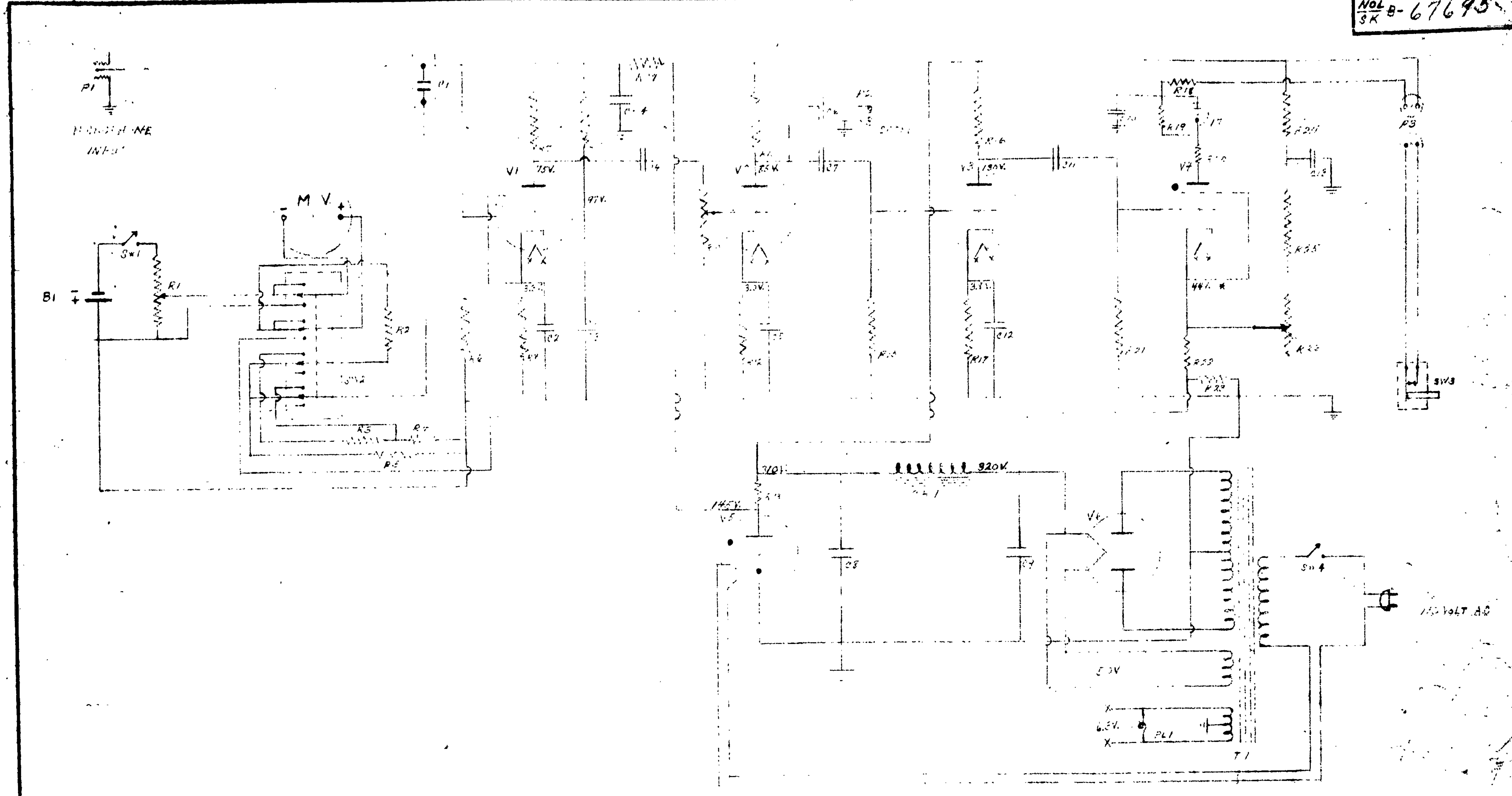


FIG. 1
300
200
100
80
60
40
20
10
Π (CM)
TNT
HBX
COMP. B
TETRYL
PETN
0
20
40
60
80
MV

NOL/SK B-67695



REVISIONS			EXAMINED	DATE
LET.	NUMBER	DATE		
A			PRIN. ENGINEER	
			ENGINEER	
			CHECKED BY	
			J.E.C. DRAWN BY	
SCALE			CLASSIFICATION	

USED ON

P. L. OR L. D.

NOTE: MATERIAL & SPEC. NO.

EXCEPT AS NOTED: TOLERANCES ON DIMENSIONS = ALL DIMENSIONS ARE IN INCHES. REMOVE BURRS AND SHARP EDGES. COUNTERSINK ALL TAPPED HOLES .031 X 90°. SPECIFICATIONS OF LATEST ISSUES APPLY.

NOISE INDICATOR FOR IMPACT MACHINE

WIRING DIAGRAM

NAVAL ORDNANCE LABORATORY

U. S. NAVAL GUN FACTORY, WASHINGTON 25, D. C.

DATE

WARNING: THE DISCLOSURE OF NATIONAL DEFENSE SECRETS IS A PENAL OFFENSE PUNISHABLE BY A FINE, IMPRISONMENT OR BOTH.

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NAVORD FORM 1597B (NOL) (REV. 3/48)